THE

Journal of the Society of Arts,

AND OF

THE INSTITUTIONS IN UNION.

111TH SESSION.] FRIDAY, MAY 19, 1865. [No. 652. VOL. XIII.

TABLE OF CONTENTS.

Announcements by the Council.

ORDINARY MEETINGS.

Wednesday Evenings at 8 o'clock.

MAY 24.—" On Anchors and Cables; their History, Varieties, and Properties." By THOMAS M. GLADSTONE, Esq., C.E.

MAY 31.—*Derby Day.* NO MEETING.

JUNE 7.—*Extra Meeting.*—" On the Policy of an Amalgamation of the Railways of the United Kingdom, under Government Management." By WILLIAM HAWES, Esq., Chairman of the Council.

CONVERSAZIONE.

The Council have arranged for a Conversazione on Wednesday, the 14th June, at the South Kensington Museum, cards for which will shortly be issued.

INTERNATIONAL EXHIBITION OF 1862.—JURY REPORTS.

The Council beg leave to announce that there are a small number of copies remaining of these Reports, which may now be had on application at the Society's House, price £1 5s. in cloth, or £1 11s. 6d. bound in morocco.

Proceedings of the Society.

TWENTY-THIRD ORDINARY MEETING.

Wednesday, May 17th, 1865; M. Digby Wyatt, Esq., in the chair.

The following candidates were proposed for election as members of the Society :—

Roper-Curzon, Hon. Sidney, Grove House, Lower Tooting, S.
Scarell, Thomas, Beddgelert, Carnarvonshire.

The Paper read was—

THE MANUFACTURE OF ENCAUSTIC TILES AND CERAMIC ORNAMENTATION BY MACHINERY.

By ZERAH COLBURN, Esq., Memb. Inst. C.E.

Wherever the feet of primeval man fell often, whether in his dwelling, on the highway, such as it might have been, in the places of traffic, or in the rude temples of the earliest religion, he must have soon learned the necessity for paving. Once accustomed to pave, experience would soon teach him to choose the harder stones and well-baked earths for the protection of his frequent paths, as well as for the preservation of the threshold and the hearth of his own home. In these uses of well-beaten and sun-dried clay, fictile art had its birth. The roughly-moulded forms employed for fire-places were soon found to harden with the heat; and, even before the vast brick-fields of Babel were worked, men might have said, " Let us make brick and burn them thoroughly." As a factitious stone the Romans made their bricks in the form of flags. At Toulouse the old Roman bricks are 14 inches long, 9 inches wide, and only 1¼ inch thick, corresponding to our own notions of tiles—the word " tile" being believed to be from the Latin root of *tego*, to cover. Ages, however, before the conquest of Gaul, bricks of nearly the same proportions had been used for paving; and flooring, in brick and stone, at first roughly practised in obedience to necessity, at last became an art. The Greeks, with their fine taste for the beautiful in form and colour, appear to have been among the first to employ mosaic paving; and their own and Roman *tesseræ* of marbles and porphyritic stones—the colour sometimes altered by burning —still survive in nearly their original splendour. These were not confined merely to tesselated arrangements, nor to kaleidoscopic combinations of geometrical forms, but they often took a pictorial character, as in the Roman pavement at Cirencester; and modern artists have shown how indestructible mosaics of this class, made not of abaciscus, but of clay cubes, or dados, smaller than dice, may almost rival tapestries in their richness and blending of colour. The pavement at Cirencester, the ancient Corinium, has, indeed, been adjudged by some of the first authorities in art to be a work of superior artistic merit. Its thirteen medallions, within as many compartments of guilloche bordering and decoration, are remarkable for the truth and precision of their figures, and they might almost be mistaken for paintings. In the late International Exhibition a mosaic pavement, by Messrs. Maw and Co., had upwards of eighty thousand *tesseræ*, mostly in quarter-inch cubes; and its five

medallions, from 1ft. 9in. to 2ft. 6in. in diameter, contained each a human head, almost living in its expression, and in which the flesh tints were graduated with remarkable accuracy, nearly rivalling the finish of portrait painting in oil. Messrs. Minton, Hollins and Co.'s mosaic pavements, exhibited on the same occasion, contained one hundred and fifty thousand cubes, of which eight thousand were included in a single classical head or medallion in the centre, and only ten inches in diameter. Although the ancients literally paved the way in the art of mosaic decoration in stone and terra cotta, we have already learned to excel the finest remains of this art in respect of elaborate design, and beauty, and careful graduation of colour; and more especially in mosaics formed wholly of natural stones, we possess a variety of materials, and an amount of skill in grouping and working them, sufficient to raise some of our productions to the level of the best examples of Florentine art. We can now command every variety of marble, whether monochromatic, variegated, or brecciated; and some of the recent mosaic pavements in the restored sacraria of certain of our cathedrals attest the value of the acquisition, to this branch of art, of the beautiful verde marbles from Connemara, near Galway. To the marbles we can bring serpentine from Mona and the Lizard, fluor spar from Derbyshire, red granite, steatite, lithographic stone, and even alabaster, aventurine, and malachite.

But mosaic decoration in natural stones must, if effective, always be costly. A recent beautiful stone mosaic, ten feet square, in the sacrarium of Chichester Cathedral, cost £200, or £2 per square foot. And it is plain that mosaics in terra cotta, where elaborate arabesques and radiating or interwining foliations are introduced—to say nothing of medallions—must be expensive also. Hence, at an early period, square tiles, curiously and richly ornamented, were employed for pavements and for walls. The decoration of the Alhambra, and of other works of the Moors while in Spain, largely consists of square tiles stamped with intricate and beautiful patterns. Many examples of this fine old Azulejo work, with the ornamental figures burnt in, or *encaustic*, in various coloured clays, are still to be found in very early structures; and in mediæval times encaustic tiles became comparatively common in church decoration. Instead of enamel, the encaustic tiles had their pattern impressed deeply into their upper or outer face, and the impression filled with one or more clays, which burnt to a different colour or colours from the body, thus leaving the pattern inlaid in the desired colour. Of course almost every tint and shade could be produced, both in the body and in the pattern, the clays in their natural state alone, without the mixture of pigments, giving a considerable range of colour. The manufacture was exceedingly simple, yet, whether from neglect, or from a change in popular taste, it had in later times become extinct; and in the beginning of the present century it might have been classed with the lost arts. There was enough, however, in the old encaustics themselves to show how they must have been made, at least, when they were carefully examined with the aid of moderate reflection and a little reasoning.

It was evident that encaustic tiles, while they admitted of a style of decoration not to be obtained in mosaic, could also be more cheaply produced, at least if the mosaic were in any considerable degree intricate; for to obtain an elaborate and varied pattern by mere tesselation, the *tesseræ* must be very small—the smaller the better, until they approach in size the scarcely distinguishable squares in needle-work patterns in coloured wools. But, as each little cube has thus to be separately made and coloured—there being, perhaps, five hundred or a thousand of these in a space only six inches square—their manufacture would necessarily be slow, and therefore costly. In encaustic, on the contrary, the square of six inches—called a quarry, from the French *carré*—would be formed in a single piece; and, the impressing stamp once made, no matter how intricate the design, hundreds or thousands of these quarries could be stamped successively, and filled in with the contrasting colour, with comparatively little labour. Ornamental tiles, it is true, are also cheaply made in majolica ware; but, however pleasing may be the forms pictured upon them, the surface of majolica is not so suitable, nor so satisfactory to the eye, as that of an unglazed tile, in its honesty of hardened clay and the genuine ingrain of its colouring.

It was in the year 1830 that the late Mr. Samuel Wright, then of Shelton, North Staffordshire, revived the manufacture of encaustic tiles, by specifying, under his patent of that date, his mode of making them. He employed a mould within an iron frame, and with a removable top and bottom, the inner surfaces of the mould being of plaster of Paris, which does not adhere to plastic clay. Once set, plaster of Paris is very hard, and hence Mr. Wright found no difficulty in forming in it the most intricately wrought designs, in alto relievo, for impressing the upper or outer surface of the tile.

It is now time to describe the manufacture of encaustic tiles as patented by Mr. Wright, from whom Messrs. Minton and Co. obtained a license, extended, by a prolongation of the patent by the Privy Council, to 1851. There are, no doubt, some gentlemen here who accompanied the Archæological Association to Shrewsbury in 1860, and who then partook of the elegant hospitality of Mr. Maw, at Benthall-hall, near Broseley, and who there listened to a very succinct and interesting account, from that gentleman, of the whole process of encaustic tile-making. While referring to that account, the author gives the following, almost identical with it, but derived from his own observations in the potteries.

The stronger and purer clays and marls, from the coal measures, as also other clays brought from the South of England, burn, without the mixture of colouring matter, into red, buff, and fawn-coloured tiles; and, with the addition of different proportions of oxides of iron and manganese, they burn into the black, chocolate, and grey tiles. The higher qualities of tiles, such as the white and those of richer colour, are made from a kind of porcelain clay, or Parian, the white being left uncoloured, while the blues and greens are coloured with oxides of chrome and cobalt. Where the clay is too strong or adhesive, from a deficiency of silica, a greater or less proportion of sand is added for the coarser tiles; but for the finer qualities, the proper proportions of silica and alumina should exist in natural combination in the clay itself. The clay is all the better if "weathered" by exposure, in thin layers, to sunshine or to frost, the effect of both of which is to break it up into fine particles, and to secure increased waxiness, if the term is permissible, in working. The clays are then, and in mixture with whatever colouring matters are employed, reduced to a state which not only potters, but many others besides, know as "slop," that is, they are mixed with water until the mixture becomes sloppy, and in this state they are strained through a sieve of fine lawn; the finer the better, and the fineness often amounts to fifteen thousand meshes or perforations in the square inch. This process of sub-division, resembling filtration, although only the coarser matters are retained by the lawn, gives great fineness and evenness to the texture of the clay, while it adds also to the brilliancy of the colour. Thus strained, the viscous clay is then dried to a plastic state, upon what are called the slip kilns. It is as well to say at once that, even for plain tiles, or those of but a single colour, two qualities of clay are taken, one for the body of the tile, the other and finer sort for the upper, or perhaps, both the upper and the lower surfaces. As in much modern furniture, so in tiles, where the visible grain and colour are but superficial, the coating of the finer material is called veneering. The workman first fills the bottom of his plaster-mould with a thin layer of the finer or veneering clay, and then beats upon it the coarser or body clay, of which nearly seven-eighths of the whole thickness of the tile is formed.

Upon the body clay he places a further coating of veneering, and upon this he closes the mould. The bottom of the plaster-mould has raised upon it, in alto-relievo, the design for the impressed pattern, and on reversing and separating the parts of the mould, and removing the tile, it is left standing with its impressed design on its upper face. In its still plastic state, the impression upon the tile is filled with a semi-liquid preparation of clay, or "slip," of a quality which burns to the contrasting colour or colours of the pattern. This "slip" not merely fills, but overflows the impression, and leaves the tile covered with a rough coating, in which state it is taken to the drying kilns, and in perhaps forty-eight hours (often much more) it is brought to the consistency of bees-wax. In this state of the tiles a workman, provided with a flat steel blade or scraper, proceeds to scrape down or shave off the superfluous coating of overflowing "slip" on the surface, and he continues this operation until he has removed it exactly down to the original surface of the tile, so as to bring out the pattern sharply and distinctly. The tile is then ready for the burning kiln. The burning occupies, in all, about a week, half the time being occupied in gradually raising the heat, and the other half in as gradually letting it down. This stage of the manufacture requires much care, as is indeed the case with all the finer kinds of terra cotta and pottery. The goods gradually shrink in burning, and the progress of the burning is indeed judged of from the appearance of proof tiles, introduced with the charge, and successively withdrawn, as the fire is got up and let down. The shrinkage is not always uniform, and tiles intended to be of the same size, inasmuch as they were formed in the same mould, often differ so much in their dimensions after burning that they cannot be laid in the same pavement. They are, therefore, carefully gauged, and assorted into lots each of one size.

Tiles so made are comparatively indestructible. A sharp file will hardly cut them, and considerable exposure to the weather affects them but little. Ancient tiles are still found, sharp and apparently unchanged in colour, where stone of strong texture has crumbled almost into dust. Care is requisite, in order that the body clay of the tile and that introduced into the pattern have equal shrinkage, as otherwise the pattern will not be firmly attached to the body. Encaustic tiles made from well selected clays and properly burnt, will not, when broken up by a hammer, show any separation of the veneering from the body, or of the pattern from the veneering. In other words, a fracture across any joint between different clays will bring off portions of both in each and every fragment broken off.

But apart from pugging the clay, and first drying and afterwards burning the tile, the process of hand-moulding is not a rapid one. A good workman will mould from 200 to 220 tiles, each six inches square, and in two colours only, as an ordinary day's work. Plain tiles, or those in one colour, are moulded at the rate of only 750 quarries, each six inches square, per day, although very rapid workmen may turn out as many as 1,000. In the Potteries it is estimated that the cost of labour only in moulding and trimming encaustic tiles is from 1s. 9d. to 6s. per dozen tiles, or from 5s. 3d. to 18s. per square yard, according to the intricacy of the patterns and the number of colours filled into them. This may be much cheaper than mosaics, but the expense is still sufficient to preclude the use of encaustic tiles in a vast number of cases, where, but for their cost, they would be most usefully and suitably employed. Where, on the one hand, the architect can command the means requisite for the best class of ornamental paving, he will naturally select the smaller and richly variegated *tesseræ*, arranging them in mosaics of his own or of some approved design; but where he is limited to encaustic tiles, the very considerable difference between the cost of the plainer and the more elaborate designs will oftener induce him to employ the former to the sacrifice of effect. And where the choice lies only between tiles and oil cloth, the latter, although not nearly so durable, will commonly produce by far the best effect for the money.

It must have long ago occurred to many persons interested in constructive and decorative art, that to introduce encaustic tiles extensively it would be requisite that they were made by machinery. It is a singular thing that the art of working in clay—possibly the earliest of all the arts practised by man—should have been almost the last to derive advantage from mechanical ingenuity. Not but that there have been many attempts to employ machinery in brick-making; but even here it is but a few years, very few, indeed, since machine-made bricks were scarcely known. It is ten years only since the first step was taken towards the manufacture of encaustic tiles by machinery; the son of the late Mr. Samuel Wright, the inventor of the hand process already described, having, as a joint inventor, obtained his first patent in 1855. The encaustic tile machine, the joint invention of Mr. Samuel Barlow Wright and Mr. Henry Thomas Green, has been successively improved, until it now appears to have been perfected, and it is in successful use in the Potteries, although not to an extent commensurate with the importance of the new manufacture. The machine is very simple, and its general construction and mode of action may be easily understood from a verbal description and without illustrative drawings. At one end of the machine are three common pug mills, placed side by side in a row, in the direction of the length of the machine. The middle and larger mill is for pugging the coarser body clay, the other mills at the same time tempering the finer clay for the top and bottom veneering of the tile. The three pug mills discharge their clay in three continuous streams, between a pair of polished rollers, which compress; and, so to speak, weld the three streams into one. This is received upon, and carried forward by, an endless travelling table, or band, which extends horizontally for the whole length of the machine. As delivered upon this table, the compound stream of clay is of the intended thickness of the tile before burning, and of a little more than its intended width. It first passes under an impression roller, perhaps two feet in diameter, and around the circumference of which are fixed the plaster dies, corresponding to the intended encaustic pattern on the face of the tile. In the old or hand process the die is flat, and the face of the tile is formed by pressing the clay equally over its whole surface. In the machine the convexity of the die does not admit of a simultaneous impression of the entire pattern over the whole surface of the tile, the place of deepest impression, at any moment in the progress of the clay, being in a line across the width of the tile. But, notwithstanding this fact, and that the alto-relievo surface of the die (being one-eighth of an inch or so further than the bottom from the centre of the impression roller) moves forward about the one-hundredth part faster than the surface which presses upon the face of the tile, the impressions are nevertheless sharp, no matter how intricate the pattern may be. The impression-roller, as well as all the other working parts, must be driven so as to correspond exactly with the progress of the travelling table, or, in other words, with the progress of the advancing stream of clay. It will be understood that the impression-roller does not revolve by friction merely, as the clay is drawn under it, but that it is driven by gearing, at a definite speed, or, as mechanics would say, it has a positive motion. As soon as the continuous slab of clay has received the intended impression, it is cut into lengths corresponding to the intended size of the tile. This is effected by a guillotine wire cutter, which rises and falls at definite intervals, cutting the clay in its descent. Although the action of this cutter is only in a vertical direction, it is so arranged that, during the brief interval while it is passing through the clay, it shall move forward with it, returning again to its original position after the cut is completed.

Simple as all the parts, so far described, may

appear to be, everything depends upon absolute synchronism in their action. A greater amount of ingenuity, or, perhaps, it will be more truthful to say, of ingenious perseverance, has been devoted to this point than those unacquainted with the constant, but seldom recorded, skirmishes on the outposts of invention, would perhaps believe. Six years ago, my friend, Professor Hughes, or rather, his representative, Mr. Henry Hyde, described in this room his beautiful type-printing telegraphic instrument, to which, perhaps, we owe the introduction of the shilling telegram, which promises to become as general throughout Great Britain as the penny postage of Sir Rowland Hill. As in Messrs. Wright and Green's tile-making machine, so in Professor Hughes's telegraphic instruments, everything depends upon synchronous action, and this has been at last secured, beyond all doubt, in both inventions. In the tile-making machine the rate of progressive motion is about twelve feet per minute, corresponding to the moulding of twenty-four 6-inch tiles per minute, or to 14,400 in ten hours, as compared with 200 or so moulded by hand in the same time. It is absolutely necessary that the pug mills deliver at the prescribed rate, that the polished compressing rollers move at that rate, and that the travelling table, the impression roller, and the guillotine cutter exactly conform to it. The rate may be 10, 12, or 20 feet per minute; but, whatever it is, all the parts of the machine must, as they do, work in perfect concord with each other.

After the advancing slab of clay has been cut into tiles, it passes under a reservoir or trough, of which indeed the procession of tiles forms the bottom, and within which the clay for the contrasting colour of the pattern is mixed with water to the consistency of "slip." The slip is filled into the impressions upon the tile, and overflows the whole surface of the tile to the depth of perhaps an eighth of an inch. The tiles are taken from the travelling table as they emerge from the end of the slip trough, and are conveyed thence to the drying kilns, where they remain until they are of the firmness of wax. They are then taken to a machine, consisting of a vertical spindle, in rapid revolution, and having one or more cutting blades fixed to its lower extremity, and revolving in a horizontal plane, as in one form of planing machine for planing wood. The tiles are placed, one by one, upon a horizontal bed-plate, which can be elevated or depressed through a small range beneath the revolving cutters, are rapidly surfaced, the overflowed slip being removed, and the pattern brought sharply out. This operation is almost instantaneous, and it leaves the tile with its two surfaces absolutely parallel with each other, and insures perfect equality of thickness in any number of tiles surfaced. Thence the tiles are squared to gauge upon the flat revolving side of a large grindstone, and, this operation being over, they are ready for burning.

The machine, with two or three attendants, does the work of from sixty to a hundred hand moulders. It works the clay more uniformly into goods than can be done by hand, and the slip pattern is deposited with more uniform density and with less risk of imprisoned air, so that the pattern burns better, and is still less likely than in hand-made goods to crack out from the body of the tile. Nothing, it is believed, can exceed the soundness and truth of the machine made tiles here upon the table; the patterns being as integral with the veneering, and the veneering with the body, as if the various clays had been actually incorporated together into one homogeneous mass. On the other hand, although the machine can make tiles with most intricate and delicate designs, even to the filiform tracery or tendril like stalks of the most curious arabesques, it can only make bicoloured tiles, as the details of the pattern can only be filled from one and the same trough of slip clay.

Another, and possibly a still more important purpose of the machine is that of making both intaglio and relievo ornaments upon slabs of plastic clay, to be burnt into terra cotta decoration for walls. In this way cheap and most durable friezes and dados, enriched antæ, and other work, whether anaglyphic or sunk, and, indeed, ornate slabs for covering the entire *façades* of buildings, may—if we disregard the extra cost of the finer clay required—be made almost as cheaply as bricks themselves. No matter how enriched may be the design, these slabs, of which we have samples here, may be produced by one machine at the rate of 5,000 square feet per day, equal to the encasing of a *façade*, allowing one half its surface for windows, of 200 feet long and 50 feet high. Such ornamentation, produced by hand moulding, has been more or less employed for a long time, but it is costly in the first place, and it is commonly made of a close-grained clay, which does not withstand the weather as it ought. By the aid of machinery, with its increased power of compression and consolidation, a more open and durable quality of clay—that is one having more silica—may be employed; and at the same time still larger slabs may be produced. The known cost of production is so low that it may be at once declared that such slabs may be sold at a cost below that of rough stone, at the quarry or without labour, the plainer slabs being sold at 6d. per superficial foot, and the enriched patterns, which are made with almost the same facility, at from 9d. to 1s. 6d. Ordinary bricks are now made by machinery, with projecting dovetails, and these bricks may be built into walls so as to project from two inches to two and a half. The terra cotta slabs are formed with corresponding grooves. When the brickwork is raised to the height of one course of blocks, these are affixed, and the joints run with cement grout; and the *façade* of slabs is secured in successive courses in the same manner until the whole is complete. In this way a building of a richly ornamented character could be erected in less time, and at as little cost, as the present unsightly structures in brick.

It may be that enough has been already said of the commercial advantages of the new manufacture. Far more might, however, be added. In the presence of so practical an assembly as this, it may be as well to enable those who are disposed to check every statement of the cost of production, to do so with the light already derived from experience in working the new machine in the Potteries. For a production of 12,000 6-inch tiles per day, or 2,000 square yards of tiles per week, about 72 tons of body clay and 48 tons of slip or veneering clay, would be required weekly. In certain localities, furnishing the required qualities, the coarser clay can be raised and moved for 3s. 6d. per ton, and the finer for 7s. 6d. per ton, including royalties, making £30 12s. weekly for clay. The coloured slips might cost £10 more. The wages of men and boys at the machine are taken at £6 14s. per week, and the cost of labour in facing and edging tiles as £25. The cost of setting, burning, and drawing the tiles may be set down as £18 more per week. The coal for drying and burning, and for the engine, may be taken as £20; the cost for warehousing, sorting, and packing as £10 per week; wages of engine-driver and fireman as £3; and wear and tear, oil and grease as £5. The cost of management, clerks, and designs would be, say £21 per week; rates and taxes, £1 6s.; commission on sales (£450 weekly at £10 per cent.), £45; stationery and advertisements, for the first year, £22; loss and contingencies, supposing them to be £20 per cent. upon the whole sales, £90; and interest on capital expended, say £30. This makes in all, £337 12s., or say £16,800 per annum. The sales, on the other hand, at 2,000 square yards weekly, for 50 weeks in the year, at the low price of 4s. 6d. per square yard, which is less than the cost of labour alone in making hand-made tiles of equal quality, would amount to £22,500, leaving £5,620 profit, or about 22½ per cent. profit upon a fixed investment of £25,000, in itself ample for the working of a single machine. The profits upon an additional investment to the same extent, in the department of terra cotta or ceramic decoration, making 30,000 square feet weekly, to be sold at 6d. per foot, would, upon the ordinary experience of

potters, be quite as great. These details, the result of careful inquiry and of accumulated experience, are given rather to show the advantages in cheapness and in the character of work obtainable in the new manufacture. The architect—as are nearly all who are engaged in the arts of construction—is more or less bound in his designs by commercial considerations; and to give him a known material at a cost commercially within the limits of general application, where previously it could only be sparingly employed, is virtually to give him a new material.

DISCUSSION.

Mr. GARLING said he had been much interested by the paper that had been brought before them. The whole operation described appeared to be a very practical one; and the details given with regard to cost and to the working of the machinery tended to give him a favourable impression of the invention. These tiles afforded a pleasing form of architectural ornamentation, and any means of cheapening their manufacture could not fail to enlist the sympathies of all interested in the progress of art. The machinery by which this object was accomplished, the particular kind of material used, and the design applied to it, were all important elements in this production, and on all these points the statements of Mr. Colburn appeared to be very satisfactory. He was not aware that any observations he could make would render more clear the explanation already given, because he thought each branch of the process had been described in sufficient detail. The designs shown were very beautiful, and the cost of production by machinery was not only a great deal less, but the results were superior to anything that could be produced by manual labour, and as these tiles would thus be made in larger quantities than formerly they would be more available to the architect and the builder.

Mr. SPENCER GARRETT had listened with great pleasure to a paper on a manufacture with which he had been connected for many years past. He had heard of this machinery from its first introduction, and it had afforded him much pleasure to be informed, from time to time, of its progress. He regarded it as a great discovery, and the condition to which it had arrived was, in his opinion, only the first-fruits of what might be looked for hereafter. The improvements still to be made were, doubtless, very considerable. He ventured to make this statement as a practical potter, and he would be only too happy to aid the progress of this manufacture by all the means in his power.

The CHAIRMAN would be glad to hear from Mr. Colburn the process by which the pattern originally made flat was brought into a circular form and applied to the cylinder.

Mr. COLBURN replied that the pattern was formed by a circular mould.

Mr. BISHOP said he had been much interested in the examination of tesselated pavements in Egypt, especially those in a mosque near Cairo. The pattern on the tiles appeared to have been produced by a stencil plate, and the glaze poured or brushed on afterwards, and then burnt in. The pattern was not indented in the tile, as was the case at the Alhambra, where he was struck with the great variety of geometrical patterns that were formed, which were of a much more distinct character of outline than these produced by the stencil. He had also seen a very beautiful description of tile in houses at Tangiers, which was evidently of the same manufacture as those used in Spain.

The CHAIRMAN remarked that there were many interesting branches of this manufacture. There was a class of tile which was ornamented by the mixture of simple clays, and another class which was ornamented by the application of vitreous colours, which were more brilliant than the natural clays, and altered the character of the tiles entirely. There was a class of tile in use in India which consisted of a combination of both these modes of ornamentation; in these the pattern was first formed by the ordinary red and white clays, and then the whole tile was floated over with a glaze which gave it another colour. Some very beautiful specimens of tiles were brought over by the late Lord Canning, and were now to be seen in the Indian Museum. The patterns on these tiles appeared to have been produced by stencilling, except in some cases where the process which was common in the Norman tiles of the north of France was employed. A star or other ornament was made in a piece of clay of one colour, and the enclosing frame, completing the square of the tile, in clay of another colour. These were then interchanged in the same manner as in marqueterie work.

A question having been asked whether these tiles could only be made in two colours by the machinery,

Mr. COLBURN replied that at present that was the limit of the applicability of the machine; and, as far as he at present knew, was likely to remain so.

Mr. MATTHEWS added that he regarded the variety of colour as a very important point. As a young architect, desirous of using these tiles for exterior decoration, he was very anxious to hear what the probabilities of the future were with regard to the production of varieties of colour, the absence of which, he apprehended, would much limit the use of these materials.

Mr. COLBURN did not see how with the present machinery more than two colours could be introduced. The whole slab of clay passed under the trough, and, in fact, formed the bottom of the trough containing the slip or thin clay which gave the colour of the pattern.

The CHAIRMAN said that, in this manufacture, the application of improved machinery to the tempering of the clay would be a great advantage. At present the methods of preparing the clay for ceramic manufacture were somewhat barbarous, and he thought might be materially improved.

Mr. GARRETT added that the process of printing paper hangings in several different colours by one machine, had furnished him with some ideas in respect of introducing varieties of colour into this manufacture.

Capt. SYMONDS, R.N., might state, in the absence of the inventors of this machine, that he had seen it in full working, and its operations were minutely explained to him. The great point which was effected by the application of this machinery appeared to be the quantity of tiles delivered in a given time, and the consequent saving as compared with hand labour. He believed he was justified in saying it was in contemplation to carry out the suggestion of introducing more than one colour into the tiles. The inventors, as might be supposed, had many difficulties to overcome in producing the specimens now shown, but they were by no means discouraged from attempting to realise higher results.

The CHAIRMAN said one of the great difficulties at present with respect to tile-making in more than two colours was now overcome by hand-labour. For instance, let them call the original colour No. 1, and the second colour No. 2. If No. 1 made a complete form, it was easy to put in No. 2 by machinery; but supposing the pattern required that No. 2 should be put in, in immediate contact with No. 1, it was obvious that No. 2 could not be put in till No. 1 had become sufficiently hard not to mix with it. That was the difficulty of getting a second pattern into the tile. As the machinery was at present constructed, the slip which formed the second colour covered the tile, and no means had yet been suggested of introducing a third colour.

Capt. SYMONDS remarked that, allowing this difficulty, there was still great advantage in manufacturing tiles by this machinery, for even if a greater variety of colour involved a subsequent manual operation, there would still be a considerable margin in cost of production in favour of the machine.

The CHAIRMAN said that no doubt this would be so. He

added, that before the discussion closed he thought it desirable to direct attention to another application of this machinery, namely, the production of ornamented slabs with indented surfaces. Those would form an admirable facing for exterior walls, and be a good substitute for the Portland and Roman cement now employed.

After a conversation relative to the cost of producing the moulds,

The CHAIRMAN said he would now offer a few general observations upon what struck him as the most important points in the paper. In the first place, they might clearly recognise the improvements now effected in the manufacture of tiles, as analogous to those produced by cylinder as compared with block printing; and the modifications which were thus being effected in ceramic manufactures were of the same character as those which cylinder printing had introduced in the ornamentation of textile fabrics. To say that the result of the application of machinery to this particular branch of manufacture had been to economise the production of it to the extent of 4 to 1, was, he believed, a moderate estimate. Of course, in calico-printing, paper-staining, and also in chromo-lithography, the operation of giving the required number of colours was comparatively easy, because each cylinder as it passed did its work immediately. The great difficulty in this case was to bring the slip into such a consistency as that it could receive and retain an impression from succeeding cylinders. The only way, he apprehended, of introducing a second colour of pattern would be, after the first slip was passed over, to remove the tile to the kiln till the slip acquired a consistency which would enable it to retain a second impression, and then to place it again in the machine. Even then it would be necessary so to arrange the pattern as to make the first impression include the second colour. When the filling-in was got into a plastic state that would again be brought to the second cylinder, and, a proper register being preserved, the tile would receive a second impression, and then the second process of pouring in the slip would supply an additional colour. It was easy to do this by hand-work, but difficult by machinery, but this appeared to him a means of getting over the principal difficulty which hung over this manufacture by machinery. With regard to the wall facing slabs to which he had called attention, the main difficulty was their safe attachment to the wall. The material was heavy, and if frost attacked the mortar behind the slab, and it became detached, there would be great danger to passengers in the street. There must be some mechanical attachment other than that which could be provided by projections on the edges of the bricks it was to be attached to, with corresponding indentations in the back of the slab. The great difficulty in this plan was to properly fit the work. The desideratum was to provide a mechanical means of attachment which should allow this facing material to be used anywhere. Having described a patent which he took out for this purpose some years ago, but which he said had lapsed from not having been brought into use, owing perhaps to public taste not having then gone in the direction of this kind of ornamentation, the chairman suggested that some ingenious individual might probably be able to make some use of it in connection with these revived methods of architectural decoration. He then went on to remark that, apart from the consideration of the improvement effected in the manufacture of tiles, they must admire the extreme ingenuity of the machinery itself. The synchronous action of the machine in all its parts was essential, but this to a mechanical mind such as Mr. Colburn's was no difficulty at all. All who designed machinery upon systematic principles, took care to bear in mind not only the motion to be made but also the time in which that motion should be made. By means of a diagram on the board, of the cylinder used in the tile-making mahine, the Chairman pointed out a method by which he conceived the difficulties mentioned in respect of the synchronism of motion in the machine might be obviated; after which he remarked that there was another aspect in which this manufacture was most important, that was, in relation to its influence upon architecture and beauty. It was important, in choosing the colours to be employed, to avoid making the contrasts crude and violent when to be seen near to the eye, though, of course, when things were seen at a distance the contrasts might be made more striking. When we had this ready means of chromatic decoration, it behoved us not to abuse it or use it wrongly, but to take care that it was directed by true principles of art. The chairman concluded by proposing a vote of thanks to Mr. Colburn for his excellent paper, which having been cordially adopted,

Mr. COLBURN expressed his gratification at the kind way in which his paper had been received, and his personal obligations to the Chairman for the able manner in which he had summed up the subject. Speaking from an architectural point of view, no doubt if encaustic tiles had been the fashion fifty years ago, machinery would have been provided to make them, but their general introduction, as was well known, had been quite recent, and it was only very lately that ingenuity had been directed to their production by machinery. The practical result they had arrived at was, that if this description of tile was wanted in large quantities, it could now be produced at such a low price that nothing made by hand-labour could compete with it.

Proceedings of Institutions.

CROYDON LITERARY AND SCIENTIFIC INSTITUTION.—The report for last year states that the directors have become the actual lessees of the building, in which hitherto the Institution has only been a yearly tenant. The balance sheet shows that the income was £1,088 17s. 10d., and that there was a balance in the hands of the treasurer of £90 18s. 11d. The following are the numbers of members enrolled during the year:—First quarter, 837; second quarter, 796; third quarter, 717; fourth quarter, 544; quarterly average, 723. In comparison with the former year, there is a decrease of forty members, and £30 less in receipts from members. There was a large addition of life members, no less than 34 having been qualified as first-class members, and four as second-class. The summer fête resulted in a profit of about £7; upwards of 2,000 attended on the occasion. 292 volumes have been added to the library during the year; 249 volumes were purchased at an expense of £46 4s. 8d. to the funds of the Institution, and 43 were presented. The total issue of books for the year was, 9,312. Thirty one lectures and entertainments were given during the year, with an average attendance of 501. Amongst these may be mentioned:—Mr. Henry Vincent, on "Oliver Cromwell; Captain James Ricket (of Cotterstock), "The Sea: Ships, Sailors, &c.;" Dr. Daniel, "Lord Nelson;" Rev. A. B. Power, on "Heat;" Rev. J. M. Bellew, "Milton;" Professor Selwyn (of Cambridge), "The Sun;" Professor R. Hunt, on "Electrical Force;" Dr. Letheby, "Oxygen Gas;" Mrs. C. L. Balfour, "Lady M. W. Montagu;" Rev. J. M. Bellew, "Shakespeare;" Mr. Elihu Burritt, "The Physiology of Nations;" Mr. George Dawson, "Great Schoolmasters;" Rev. J. B. Owen (of Chelsea), "Cliques." Several were given gratuitously. The Committee mention with regret that Mr. F. Warren has announced his intention of retiring from the hon. secretaryship at the end of the present year. Mr. Warren has been the mainstay and the life of the Institution, and at the urgent solicitation of the Committee, he has reluctantly consented to continue his valuable services for another year.

YORKSHIRE UNION OF MECHANICS' INSTITUTES.—The annual meeting will be held at Stockton-on-Tees, on

Thursday, 8th June, in Whitsun-week. In the forenoon the conference of delegates will be held in the Borough-hall, when Mr. Edward Baines, M.P., the president of the union, will take the chair. The report of the Central Committee will be presented, and several interesting questions will be submitted for discussion. In the afternoon the delegates and other visitors will dine together at the Black Lion Hotel; and in the evening a public meeting will be held in the Borough-hall, at which the Right Hon. Thomas Headlam, M.P., Judge Advocate-General, will preside. On the Friday the delegates will have an opportunity of visiting the extensive iron ship-building yards in the neighbourhood, after which they will be conveyed by special train to Gisborough, to see the ironstone mines whence are derived the great mineral treasures of the Cleveland district; and the beautiful and picturesque seat of the Earl of Zetland, at Upleatham. They will then proceed to Saltburn, the new watering-place on the North-Eastern coast, where luncheon will be provided.

Fine Arts.

PARIS EXHIBITION OF FINE ARTS.—This exhibition was opened on the 1st day of May, as usual, without any previous private view. The Emperor visited it just before leaving for Algeria. It is fortunate that Paris possesses such a building as the *Palais de l'Industrie*, otherwise it would be very difficult to find a place for these annual exhibitions, which are assuming colossal proportions. Last year the total number of works admitted by the jury, and exempt from previous examination, amounted to 3 086, including all classes—paintings, drawings, miniatures, enamels, sculpture, architecture, engraving, and lithography. This year the total is 3,559, although certainly the admission jury has not been more lenient upon the present than it was on the last occasion. The exhibition in separate rooms of such of the rejected works as their authors chose to leave for that purpose has not been repeated. Last year there were 1,150 pictures refused, two-thirds of which were immediately withdrawn by their authors, and the exhibition of the rest had such an effect that no one desired a repetition of the show. The rewards consist of two grand medals of honour, each of 4,000 francs value, forty medals, of the value of 400 francs each, in the section of painting, fifteen in that of sculpture and die sinking, six in architecture, and eight in engraving and lithography. In addition the jury has the privilege of recommending for the Legion of Honour any artist who may have received one of these medals on three occasions. All the medals are awarded before the opening of the exposition, and labels inform the public not only which works or which artists have obtained prizes, but also whether they were admitted by right, the artist having previously received certain distinctions or after examination by the jury; or whether they were *hors de concours*, in consequence of the artist being a member of the jury. The grand medals of honour have been bestowed upon M. Cabanel for painting, and M. Paul Dubois in sculpture. M. Cabanel's reputation is well established; he is one of the professors of the new governmental school of the Beaux Arts, a member of the *Institut*, and the painter of many works known by their photographs all over Europe. Amongst these, perhaps, the beautiful oval, *Aglaé et Boniface*, is the purest and most remarkable. M. Cabanel has only two portraits in the exhibition, but one is of the Emperor, who is painted in plain dress. M. Cabanel's is a very remarkable work, curiously unlike that of Flandrin in almost every respect; he has softened the features of Louis Napoleon, but he has shown more of the intellectual character than his predecessor. As regards technical execution this portrait is excellent. The other portrait is that of a lady in a purple velvet dress, a most refined and exquisite work. M. Paul Dubois, to whom the other grand medal of honour has been awarded, is a much younger man, who obtained a third class medal for sculpture in 1863, but failed to obtain any reward last year; the work which has thus been crowned is very charming. It is a statue of a Florentine youth, in the costume of the 15th century, singing to his own accompaniment on the lute. The face is full of serious energy, and the half-developed muscles of the youthful form exhibit intense study and most delicate handling. M. Dubois, like the great sculptors of old, does not confine himself to one phase of his art, but exhibits this year, as he did last, also in the section of drawings and sketches. He is a native of Nogent-sur-Seine and pupil of M. Toussaint, but not a laureate of the Academy. The works belonging to the class of painting are no less than 2,243 in number, against 1,995 last year. Two circumstances, amongst others, have contributed to alter, to some extent, the general character of the exhibition. In the first place, the absence of war, and the surfeit which the public has had of huge flashy battle pieces, have at once lessened the number of such works and greatly improved the remainder. The most remarkable battle piece in the Exhibition, a "Charge of Artillery," by M. Adolphe Schreyer, a young artist of Frankfort, (only known in the Paris world as having obtained a medal last year for a landscape with horses, which has been purchased by the government, after having been rewarded with a medal by the jury) is a simple, bold, serious work of high character. The whole main plan of the picture, which is large, is occupied by a gun, drawn by six horses with two artillerymen on horseback. The soldier who rides the near wheeler is wounded and falling back in his saddle, the horse has become entangled in the harness, and hangs back, while the others in full gallop drag it along. M. Pils, who gained the grand medal for his picture of the French part in the battle of the Alma, in 1861, and who is now one of the Professors of the Ecole des Beaux Arts, introduced, or at any rate confirmed, this new and wholesome mode of dealing with military subjects, which is adopted by Bellangé, Protais, and other eminent French artists. Of the other Professors of the School of Fine Arts, M. Robert Fleury, the director, does not exhibit, but M. Gérome contributes two works—one, a picture, painted by command, of the reception of the Siamese embassy by the Emperor at Fontainebleau. The Siamese are on all fours in the centre of the room, with the exception of the chief ambassador, who has reached the foot of the throne and presents his master's letter to the Emperor. The magnificent presents are on the steps of the throne, and there is a group of ladies behind the Empress. M. Gérome's other work, "Mussulmen praying on the house tops," is an effective picture. Amongst the most prominent works, besides those already mentioned, are two pictures in mediæval style by M. Alma Tadema, a pupil of Mr. Leys, of Holland; "Youth," by Aubert; "A Diana," by Baudry, who, however, has not achieved a great success this year; "The charge of the French cuirassiers at Waterloo," after Victor Hugo, by Bellangé; "Twelfth day in Alsace," by Gustave Brion; "A Jewish schoolboy of Tangiers," by Madame Henriette Browne; two charming groups of children, by Charles Chaplin; two pretty diminutive pictures, by Victor Chavet; two landscapes by Corot, in the great room, which were thought so admirable by half of the jury that they desired to bestow the grand prize upon that artist, and it was only finally awarded to Cabanel after 28 turns of the ballot-box—both being members of the jury; a fine moonlight scene, and a view of the park of Saint Cloud, by C. F. Daubigny; "Venus and Cupid," by Eugéne Faure; "View of the new excavations at Pompeii," by Français; "Falconry in Algeria," and "Robbers of the Sahara," by Fromentin; "Portrait of a lad in Turkish costume," by Gautier; a "Presentation," and "Monks at their studies," by Gide; "The death of the Princess de Lamballe in 1792," by Firmin Gerard; "Arrival of the Emperor Napoleon III. at

Genoa," a marine scene, by Gudin; Two charming little works by Herbert, entitled "La Perle Noire" and "The Stone Seat;" "A child's head," by Leopold Horovitz; "The Alchemist," by Isabey; "A Scene on the Sea Shore," by Le Comte; "Hylas," by Lenepken; "Skarga preaching before Sigismund III.," an excellent attempt at historical painting by a young Pole, pupil of the school of Cracow, and for which a medal has been awarded to the artist, Jean Matejko; two works by Meissonier; and the first exhibited production of his son, Jean Charles; the last-named is on a larger scale than the works of the elder artist, but the treatment is of the same kind and promises well; "Jason," and a composition entitled "The Young Man and Death," by Gustave Moreau, the painter of the "Sphynx," which was the most remarkable picture of last year's *salon;* Interiors of the galleries of the Louvre and of Fontainebleau, by Navlet; "A fête in the time of Henry II.," by Arnold, son of Ary Schaeffer; "Cinderella," by a Belgian artist, Joseph Van Lérins; "The Empress Josephine before the coronation," by Viger-Duvignau; and two views in Venice and Verona by Mr. William Wyld. A large number of eminent names are absent from the catalogue, and some of the ablest of the exhibitors have sent works of small importance; but on the whole, however, there is such immense profusion and variety, such a general acquaintance with form, and so much power in its delineation, so much knowledge of colour and harmony, although, according to English notions in general, pitched in too low a key, that no young artist, who can afford to pay an annual visit to the Paris exhibition, should omit to do so. He can find nowhere else such a mass of contemporary art, or see at once the works of so many existing schools, for the Paris exhibition includes a large number of works by other than French artists. The total number of painters exhibiting is 1,567, of whom 1,300 are French, and 267 belonging to other countries. Of the latter 60 are Belgian, 34 Prussian, 31 from other parts of Germany, 21 Swiss, 19 Italian, 17 Russian, 17 Dutch, 14 Austrian, 12 Spanish, 9 English, 9 American, 5 Polish, and as many Swedish, 4 Norwegian, 3 Hungarian, 2 Danish, and as many Hanoverian, and one each from Portugal, Peru, and Egypt. But of these 267, rather more than one quarter, have been educated, either wholly or in part, in France, and thus belong to the French school. Of the wholly foreign element the Belgian is by far the most important, there being fifty artists educated in Belgian schools in the list of exhibitors. The next most important element is the Prussian, and indeed, taking the whole of Germany together, its artists rather exceed those of Belgium. Half the Swiss exhibitors have been educated in France, but less than a third of the Italians and Russians, while nearly the whole of the Austrians and Dutch are educated in their own countries. It appears by the official report itself that there were alive on the 1st of January in the present year 800 painters, 200 sculptors, 160 architects, and about 130 engravers and lithographers, who had received medals or other honours.

Manufactures.

ANGLO-FRENCH WORKING-CLASS EXHIBITION.—An International Working-Class Exhibition is now being organized by a committee of English workmen, with whom their French brethren appear to be heartily co-operating, and the present year being the fiftieth anniversary of peace between Great Britain and France, may be regarded as a peculiarly suitable opportunity for such an undertaking. It will be held at the Crystal Palace, Sydenham, and is to be opened on Saturday, July 29th, and to remain open during the months of August, September, and October. Among the patrons are M. Michel Chevalier, M. Girardin, M. Arles Dufour, Thomas Baring, Esq., M.P., G. J. Goschen, Esq., M.P., Stephen Cave, Esq., M.P., Charles Buxton, Esq., M.P., Walter Morrison, Esq., M.P., Robert Hanbury, Esq., M.P., George Lyall, Esq., M.P., and J. G. Hubbard, Esq., M.P. English and French employers and workmen are invited to send specimens of skilled work; journeymen to exhibit in their own names; and employers, in addition to their own, must state the names of the men who made the articles shown. Clever workmen will thus have an opportunity of obtaining public recognition of their skill, while firms who employ them will, in all probability, extend their business by sending highly-finished goods to this the first international working class show. Prizes will be given for excellence of workmanship, and a bronze commemorative medal will be presented to every exhibitor as a souvenir of the peace jubilee. To enable exhibitors to superintend and arrange their goods, a free pass for the season will be issued to each person whose work is accepted; but the committee wish it to be distinctly understood that they do not bind themselves to accept every article offered. All articles sent for exhibition will be taken the greatest possible care of, but the committtee will not hold itself liable for any loss or damage whatever. Things may be sold, but not removed until the close of the Exhibition. French workmen living in London are especially invited to compete with their British friends upon this occasion. It appears that a deputation from the London Committee was received with great enthusiasm in Paris; and at a meeting of delegates from the various Trade and Co-operative Associations, held at the offices of the Society of Crédit au Travail, a committee was formed who will receive goods from all parts of France and forward them to the Crystal Palace. From the ready support given to the movement by all classes in Paris, a very imposing collection of French goods is anticipated. English exhibitors are requested to make early application for space, which will be granted free, but all goods intended for exhibition must be delivered, carriage paid, at the Crystal Palace, not later than July 22nd. All articles not sold must be removed from the Crystal Palace within a fortnight after the close of the Exhibition at the exhibitor's own expense. For further particulars, forms of application for space, &c., apply to the Secretary, Mr. R. Coningsby, Crystal Palace, Sydenham; or to M. Edmond Potonie, 3, Rue Baillet, Paris.

MANUFACTURES IN IRELAND.—A meeting was held on the 12th instant, at 29, Cannon-street, to consider the best means for introducing new and extending existing manufactures in Ireland. The chair was taken by the Marquis of Clanricarde, and among those present were:—Lord Dunkellin, M.P.; Colonel Dunne, M.P.; J. Pope Hennessy, M.P.; J. F. Maguire, M.P.; J. A. Roebuck, M.P.; Colonel French, M.P., and many others. The Chairman said they had met to consider what description of manufacture should be introduced into Ireland so as to receive the support of English commercial men. He was sure if a company were formed it would receive the best support which himself and other gentlemen could give. Mr. J. O. Lever, M.P., then explained that the object proposed was to erect a number of mills in different parts of the country, for weaving union cloth, an article in extensive demand, composed of linen and cotton. They contemplated the erection of ten mills for the purpose, and proposed to employ a capital of £1,000,000, consisting of 5,000 debenture bonds, bearing 6 per cent. interest; £200,000, in 10,000 shares to be applied in payment for land, &c., in Ireland; a like sum to be applied in payment for machinery in Lancashire; and 5,000 £20 shares for allotment and distribution to the public. He had found some of the best engineers in England who were willing to supply the machinery, taking one-fifth of the cost in shares and giving reasonable time for the payment of the remainder. They contemplated employing a new patent of Mr. Dickson for spinning the cotton and flax in the same yarn, by which one of the objections to ordinary union cloth would be obviated. The cost of erecting the mills would be £1 per spindle. Mr. Maguire, M.P., did not think mills could be erected at so low a cost. Mr.

Kirk stated that the erection of mills at the price named was easily accomplished. Mr. Dickson said he had tried his plan to some extent, and it had proved remunerative. After some further discussion, the following gentlemen were appointed a committee to consider the subject:—The Marquis of Clanricarde; J. Ennis, Esq., M.P.; Lord Claude Hamilton, M.P.; J. F. Maguire, Esq., M.P.; Colonel Ffrench, M.P.; R. P. Dawson, Esq., M.P.; J. O. Lever, Esq., M.P.; and J. Pope Hennessy, Esq., M.P.; with power to add to their number.

Colonies.

THE CENSUS OF CANTERBURY gives the population of the province at 32,253 souls, of whom 18,932 were males and 13,321 females. The total number of acres of land fenced was 342,416, of which there were in wheat, 13,328 acres; in oats, 14,672 acres; in barley, 2,432 acres; in maize, 107 acres; in potatoes, 1,752 acres; in gardens and orchards, 220 acres; in artificial grasses, 31,670 acres; and other crops, 2,564 acres. The stock returns of the province give 10,868 horses, 62 mules and asses, 45,263 cattle, 1,567,320 sheep, 769 goats, 10,228 pigs, and 73,745 poultry. The census of 1862 gave the population at 16,040, so that it has more than doubled in three years.

THE STATISTICS OF WELLINGTON show the population of the province to be 14,938, an increase during the last three years of about 18 per cent. The total quantity of land under crop, exclusive of artificial grasses, was 8,130 acres. Of land under grass there were 90,286 acres. The live stock—7,265 horses, 49,200 cattle, 401,502 sheep, pigs 13,072.

TRADE OF MARYBOROUGH, QUEENSLAND.—The gross value of the imports during 1864 was £112,412, and the gross exports during the same period were £123,246, and it is expected this year that coal, sugar, and other articles will be seen in the list of exports.

PROGRESS OF QUEENSLAND.—Marked progress was made last year in the Wide Bay district. Notwithstanding the severe test brought to bear on the farming population by the disastrous floods at the commencement of the year, the agricultural prospects are very promising. A large quantity of land has been taken up during the year, and a considerable increase made to the number of farmers resident on the Mary. Much attention has been directed to sugar-growing. A large area has been devoted to the growth of the cane, and two sugar mills are being obtained from England. During most of the year the timber trade has been greatly developed, and the immense cedar and pine forests have been keeping three local saw mills in active employment. Pastoral interests have been steadily advancing. The Burnett, although tested by two or three wet seasons, has maintained its high reputation for the growth of wool and healthiness of its sheep; and while other parts of the colony have been suffering from pleuro-pneumonia, neither the Wide Bay nor Burnett has exhibited a solitary case of that deadly scourge. A very fine seam of coal has been discovered on the Upper Mary, cropping out on the bank of a navigable portion of the river.

Notes.

GEOLOGISTS' ASSOCIATION.—The first excursion of the season took place on Tuesday, the 9th inst., when the members visited Swindon, to examine the beautiful sections of Portland oolite, Purbeck, and green sand, which are displayed in the quarries of that neighbourhood.

WORKING MEN'S EXHIBITION FOR THE CITY OF LONDON.—A deputation of members of the committee formed for organising a "Working Men's Exhibition for the City of London," waited by appointment upon the Lord Mayor on Thursday, the 11th May, to present a requisition signed by nearly 2,000 working men, and to solicit his lordship's co-operation in promoting such an exhibition. The deputation was introduced by Mr. Deputy Obbard. His lordship consented to take the matter into consideration and communicate with the secretary at an early date.

Correspondence.

WEAR AND TEAR OF STEAM BOILERS.

SIR,—A letter from Mr. D. K. Clark, in your last impression, conveys against me a charge of plagiarism in a way as courteous as it appears to me unmistakable. If I do understand that gentleman rightly, he labours under the slight misapprehension of thinking that I derived the explanations I gave of the pitting and furrowing of boiler plates from his work on the "Recent Practice in the Locomotive Engine." As he was so good as to re-publish last week, in your columns and those of a contemporary, all he has written on these subjects, and as I had the pleasure of laying the results of my little investigations before the Society on the 26th ult., anybody who chooses to take the trouble can easily form his own opinion on the sufficiently-unimportant question at issue. But I fear that few will take this trouble, and therefore, in justice to myself, I shall now proceed to show, in an easily-accessible form—

1. That my explanations, such as they are, of the phenomena of pitting and furrowing are quite distinct from those given by Mr. D. K. Clark.
2. That everything which he adduces as explanatory of furrowing and pitting was published by others years before the issue of his work on the "Recent Practice in the Locomotive Engine."
3. That such publication could hardly have been unknown to Mr. D. K. Clark at the time (1860) he published his own book.
4. That the very little information I have derived from his work has been fully acknowledged by myself.

I will now proceed to prove these small matters by a verbatim reference to the original documents:—

MR. D. K. CLARK'S THEORY, *in extenso*, OF THE PITTING OF BOILER PLATES.

(Published in 1860, at page 15 of "Recent Practice in the Locomotive Engine.")

"*Furrowing of Boilers at the Joints.*—Probably the most important practical reference to be drawn from the tests of the strength of rivetted joints, is the explanation they supply of the failure, hitherto unexplained, of boiler plates, not at the joints, but in their neighbourhood. We are aware that electrical and galvanic action are freely adduced in explanation. But these words have two meanings—they mean electricity and galvanism; and they mean ignorance and mystery. It is known that boilers fail by corrosive and other agencies eating into the plates on the inside, pitting and furrowing the surface. The pitting of the metal is readily explained by the presence of chemical agents in solution in the water, and the known inequality of substance of iron plates and bars, in consequence of which the metal is gradually but unequally separated and dissolved; and probably a weak

A PORTION OF YOUR CORRESPONDENT'S EXPLANATIONS.

(See the "Society of Arts' Journal" of April 28th, p. 394.)

"..... The presence of a concentrated solution of an acid or alkaline character, kept at a high temperature for years in contact with iron plates, would be sufficient to account for much corrosion. But the internal corrosion of steam boilers has many features of such a mysterious character, that no accredited explanation of its attendant phenomena has yet been put forward. In the first place, plates thus attacked show a number of irregular holes, like a pock-marked human face, or like the small craters seen on the moon's surface. The writer has also sometimes observed two or three little irregular excavations like this in a plate otherwise showing a large surface quite intact. Sometimes the plate is most pitted round a projecting bolt; at others, one plate will be perfectly sound, while that rivetted to it will be almost eaten away, both having been the same time at work, and under, of course,

galvanic circuit may be established between the iron shell and the brass tubes, accelerating the process of dissolution."

Most of the above is contained, almost verbatim, in the following letter, addressed by Professor Tyndall to Lieut.-Col. Wynne, R.E. It was printed and published in 1856, in the very same "Report of the Board of Trade on Railway Accidents" to which Mr. D. K. Clark refers at page 15 of his book. This letter was also included in a circular sent, in 1855, to all the railways in the United Kingdom by the Board of Trade.

"MY DEAR SIR,—In placing before you the reflections suggested by our joint examination of the boiler which exploded some time ago at the Swindon Station of the Great Western Railway, I have to express my regret that the absence of safe experimental data on the question of steam boiler explosions generally, renders every opinion upon the subject in a great degree conjectural and uncertain. Our two hours' examination, instead of enabling us to assign the exact source of the actions which led to the destruction of the boiler, merely suggests the mode of attacking the question. While venturing, therefore, upon the following remarks, I cannot help feeling how much more satisfactory it would be to be able to substitute for supposition, however probable, the surer evidence of experimental fact.

"The appearances presented by the boiler were as follows:—The iron plates, as far as the water usually extended, were deeply pitted and furrowed by some corrosive agency. At the centre portion of the boiler, the pits, I think, were deepest and best defined; towards the end at which the cold water entered to feed the boiler they were less pronounced; towards the end nearest to the fire-box they were more diffuse and general. While pondering over these curious appearances, my attention was attracted by the tubes which passed through the boiler; these were of brass, and were attached at one end to the fire-box, and at the other end to the smoke-box of the engine. In the normal condition of the boiler these tubes were separated from the bottom and sides by an interval of an inch or two, this interval being usually filled with hot water.

"Without pretending to a degree of confidence unwarranted by the circumstances of the case, I think it may be apparently exactly similar conditions. With locomotive boilers this pitting has been ascribed to galvanic action between the brass tubes and the iron plates. But it is notoriously well known to locomotive superintendents that boilers with iron tubes are often worse pitted than those which have run the same distance with brass tubes. Besides, all iron boilers, with or without brass, whether used for stationary, locomotive, or marine purposes, are subject to pitting.

"An explanation which seems to meet all the circumstances of the case is the following:—Mr. Mallet, in a report addressed to the British Association some years ago, showed that wrought iron and steel (blister steel probably) 'consist of two or more different chemical compounds, coherent and interlaced, of which one is electro negative to the other.' In fact, ordinary wrought iron, being also welded up from differently worked scrap, is far from being an electro-homogeneous body. In a boiler, the hot water, more or less saturated with chemical compounds, is the exciting liquid, and the electro-positive portions of the plates are thus quickly removed to a greater or less depth. This explanation meets most of the known circumstances with respect to pitting; it even, in a great measure, explains how plates above the level of the water, especially in marine boilers, get very rapidly corroded in portions, while another part of perhaps the same plate is scarcely affected. The concentrated water in a marine boiler is known to be generally acid. 'Of all the salts contained in sea water,' says Faraday, 'the chloride of magnesium is that which acts most powerfully on the plates. He shows that a cubic foot of sea water contains 3·28 oz. of this salt, and at the same time, points to the danger of voltaic action in a boiler through the contact of copper and iron. In a smaller degree, the contact of cast with wrought iron, or between the different makes of wrought iron in the same plate, or between contiguous plates, acts in the same way. It is not improbable that some hydrochloric acid is present in the steam of marine boilers. 'Mr. J. C. Forster has tested some of the condensed steam from the safety valve casing, and from the cylinder jacket of the Lancefield, and found both decidedly acid.' With an exciting liquid in the condensed steam, it is thus explicable how the plates of marine boilers often get corroded in a most capricious manner; while, at the same time, the current of steam would create a certain amount of friction on the oxide, clearing it away to act on a fresh surface.

The crucial test of this explanation of pitting would be the observation of the absence of the phenomenon from plates of an electro-homogeneous character. This homogeneity could only be expected from fused metal, such as cast steel. Accordingly, while the writer was in Vienna a short time ago, he was assured by Mr. Haswell, the manager of the Staatsbahn Locomotive Works, that some locomotives made of cast steel plates, in 1859, for the Austrian Staatsbahn, had been working ever since without showing signs of pitting, though under similar conditions iron plates had severely suffered in this way. Pitting may thus be fairly defined as a form of corrosion localised to particular spots by voltaic action. It is also probably aggravated through the motion of the plate by mechanical action, and the expansions and contractions from alterations of temperature. All boilers are most pitted near the inlet for the feed water, and with inside locomotive boilers there is generally more pitting at the smoke-box end—no doubt caused by the more or less racking action on these plates. A state of corrosion at particular spots would probably be kept up to a greater intensity by the incrustation being mechanically thrown off. With a quicker voltaic action caused by any unusual intensity of the exciting liquid, the sides of the cavities in the plates would be sharper, and less rounded off; as in the case of the boiler fed with mineral water from ironstone workings, which exploded last year, at Aberaman, South Wales."

affirmed that such a boiler constitutes a veritable voltaic couple, consisting of brass, iron, and the exciting liquid, water. Feeble currents of electricity will be established, the direction of which through the liquid will be from iron to brass, the iron being what is called the positive element of the couple. A decomposition of the water will take place, hydrogen will be liberated against the brass tubes; oxygen (and acid, if a salt be dissolved in the water) will be liberated against the iron plates. The quantity thus evolved may be very small, but, acting incessantly for a number of years, it would, I imagine, be sufficient to produce the observed corrosion.

"In the course of our examination you directed my attention to the singular preservative influence which the fire box seemed to exercise on some iron bars which passed through it. There were, I believe, four such bars—solid cylinders, which passed, as longitudinal stays, from the front to the rear of the engine. Up to the point where these bars entered the steam dome they were deeply corroded; in the steam dome they were comparatively unaltered. This seems to be in harmony with the foregoing explanation. Up to the steam dome the iron bars ran side by side with the brass tubes which traversed the boiler; at the steam dome the brass tubes ceased, and from this to the end of the boiler, the iron bars, instead of being electromotors, were merely the conductors of the currents generated where the bars and the tubes were in close proximity. Other explanations may possibly be suggested, the exact merits of which experiment alone can decide.

"Parallel to the row of rivets which united the bottom plate of the boiler to the smoke-box, a deep furrow had been eaten into the plate. A similar corrosive action was not observed parallel to the corresponding row of rivets at the fire-box end. Parallel to one longitudinal row of rivets a furrow had been eaten so deep as to reduce the thickness of the plate from three-eighths to less than one-eighth of an inch. Along this furrow the boiler is supposed to have given way; the plates were torn asunder, and the total destruction of the boiler was the immediate consequence.

"Now, whatever be the cause of the corrosion, whether we refer it to the oxygen held in solution by the water, or to the decomposition of the water itself, science probably furnishes the means for its prevention. The experiments of Pepys, Davy, Van Beck, and others show that, by suitably connecting a more positive metal with iron, the corrosion is diverted from the latter, so that it is thus possible to preserve iron uninjured in a liquid which, under ordinary circumstances, would rapidly attack it.

"If the explanation which refers the corrosion to electro-chemical decomposition be the correct one, then in boilers where iron tubes are used, instead of brass ones, the pitting and oxidation ought not to take place to the same extent. I say 'to the same extent' because a difference in the manipulation of two pieces of iron is sufficient to destroy their electro-homogeneity, and to produce feeble currents when the pieces

are immersed in an exciting liquid. An action of this kind may, perhaps, be established between the iron rivets and the plates they unite, and, possibly, to this cause may be referred the furrows which are sometimes observed to follow the lines of junction. It would, however, be hasty to infer from a single instance that this is a general result; the whole subject demands a thorough examination, and a far wider acquaintanceship with facts than two hours' inspection of a single boiler could possibly furnish.

"The longer we reflect upon this subject, the more deeply must we be impressed with the necessity of associating, in the construction and management of steam boilers, the knowledge of the natural philosopher with that of the engineer. The consciousness of our deficiency in this respect was present with me when, on a recent occasion, I ventured to state that 'there are agencies at work in a locomotive of which the maker of it never dreamed, and which may, nevertheless, convert it into an engine of destruction.' At the present moment it might be difficult to say how many boilers are on the verge of explosion without any single engineer being aware of the danger. Another point deserving of attention is the following:—Common water always contains a quantity of atmospheric air in solution. This air may be expelled from the liquid by continued boiling, and it is an experimental fact that water thus freed from air possesses mechanical properties widely different from ordinary water. The cohesion of the liquid is enormously increased, in consequence of which it may be heated to a temperature far beyond its ordinary boiling point without boiling; but when it does boil it is not with the quiet ebullition of common water, the liquid particles snap suddenly asunder like a broken spring, and ebullition is converted into explosion. It is, I believe, a fact that boilers, after standing for a time, have often exploded at the precise moment when the engineer turned on the steam. The question presents itself, whether the action just referred to may not here come into play? If the water has been sufficiently purged of air and then left at rest, its augmented cohesion may permit of its being heated far above the boiling point due to the pressure upon its surface; the mechanical disturbance produced by turning on the steam would destroy this cohesion, and the superheated liquid would develop a force resembling that of gunpowder on the application of a lighted match. I would wish it to be borne in mind that we are in total ignorance as to the practical value of these suggestions; but the investigation which the subject so pressingly demands must take cognizance of them all.—I am, &c.,

"(Signed) JOHN TYNDALL.

"Lieut.-Col. Wynne, R.E., &c., &c."

The explanation I put forward differs, therefore, *in toto* from that of Mr. D. K. Clark. He first accepts the common stoker's notion of pitting, and ascribes it to some parts being "softer" than others. With this he jumbles up Professor Tyndall's observation about the brass tubes. He is entirely unaware of the three facts, amongst others, the bringing together of which has enabled me to put forward an explanation of the pitting of steam boilers:—1. That boilers with iron tubes are often more affected than those with brass tubes; 2. That cast steel boilers are not affected in the form of pock marks at all; 3. That common plate consists of interlaced portions, which are not electro-homogeneous—an important observation first made by Mr. Mallet, whom I quote. The weak galvanic circuit between the iron shell and the brass tubes, first alluded to by Professor Tyndall, and then adopted by his disciple, Mr. Clark, might account for an equally spread corrosion, but not for the "pock-marks." In truth, it has been noticed by many observers, amongst whom is Professor Faraday, that ordinary zinc plates in a galvanic battery are pitted in just the same way, and with an attendant loss of discharging force. Of course, Mr. D. K. Clark may have known every one of these things, but it was scarcely kind to his readers not to have published them.

MR. D. K. CLARK'S THEORY, *in extenso*, OF FURROWING.

". . . But this explanation does not meet the frequent case of a straight continuous furrow, cut like a groove, upon the surface. Furrows are observed to be formed parallel to, and close to, the rivetted joints. Not in any case, that we are aware of, have they been found at any notable distance from a rivetted joint, nor otherwise than parallel to one. The inference is inevitable that there is a relationship betwixt them; and our conviction is, that the alternate tension and relaxation of the plates at the joints, as the steam is got up and let down, are attended by an alternate distortion—incipient it may be—and resumption of the normal form, a bending and unbending of the plate on each side of the joint; in consequence of which the texture of the metal is gradually loosened in lines near to, and parallel to, the joint, and it is thus open to corrosive action. On this interpretation, the commencement of a groove or furrow, establishing a weak place, and concentrating the action there, would suffice to extend and deepen it to the dangerous limits occasionally announced by explosion.

"The weakness attendant on lap joints is strikingly exemplified in the lap-welded joint when subjected to extreme tension; the tensile strength, though the metal at the weld is perfectly solid and fully as strong in itself as the body of the plate, is much below that due to the regular section of the plate. Here there is no elementary weakness in the reduction of metal by rivet-holes; the inferiority of strength arises solely from the bending of the plates on both sides of the lap, and the over-straining of the fire-box in the endeavour to attain the position of stability.

"Mr. John Sewell, commenting on the corrosion of locomotive boilers, ascribes the furrowing of plates at rivet joints to the interruption of the vibrations of the boiler by these joints, the localisation of the fatigue at these places, and the increased susceptibility, in consequence, to corrosive action. This action has, doubtless, a tendency to aggravate the evil of lap-jointing; but we are disposed to ascribe the evil to the lateral bending and unbending of the plates as the primary cause.

"The furrowing of lap-jointed plates reads an important lesson on the real and intimately practical value of direct connection and direct action in exerting, transmitting, or resisting forces. That the furrowing of plates at the rivetted joints results from the indirectness of the strain of the steam pressure, is rendered still more probable by the analogous furrowing which results from reciprocating strains of another kind. In the more ancient classes of engines, in

A PORTION OF YOUR CORRESPONDENT'S EXPLANATION OF "FURROWING." (p. 388.)

. . . . . . "Emerson showed, more than sixty years ago, that the stress tending to split in two an internally perfectly cylindrical pipe, submitted to the pressure of a fluid from the interior, is as the diameter of the pipe and the fluid pressure. He also showed 'that the stress arising from any pressure, upon any part, to split it longitudinally, traversely, or in any direction, is equal to the pressure upon a plane drawn perpendicular to the line of direction.' As in a boiler the thickness of the metal is small compared with the radius, the circumferential tension has been assumed to be uniformly distributed; and the strain per unit of length upon the transverse circular joint being only half that upon the longitudinal joints, the strength of the latter has been taken as the basis of the calculations for the tensile strength of the joints. But in taking the internal diameter of the boiler as the point of departure, the internal section has been assumed to be a correct circle, which would only be practically true in the case of a cylinder bored out in a lathe, and never in that of a boiler. Two of Emerson's corollaries from his first proposition have in fact been neglected. He shows that if one of the diameters be greater than another, there will be a greater pressure in a direction at right angles to the larger diameter; the greatest pressure tending to drive out the narrower sides till a mathematically true circle is formed. The second is that if an elastic compressed fluid be enclosed in a vessel, flexible, and capable of being distended every way, it will form itself into a sphere.'* A number of proofs can be adduced that both these influences are more or less at the bottom of the wear and tear caused by the direct action of the steam.

"From 1850 to 1864 forty locomotive explosions, causing a loss of human life, have occurred in the United Kingdom. The Board of Trade reports in the blue-books presented to Parliament, and more especially those by Captain Tyler, R.E., probably form the most valuable and connected series

* The action of a fluid pressing with equal forces in all directions can be evidently represented as to force and direction by innumerable radii of equal length led from a single point in all directions. Upon this principle may be explained the spherical shape of soap bubbles, or the bulbs of thermometers (blown while the glass was in a plastic state), of the thin india-rubber balls used as playthings, and which are formed by forcing air into india-rubber tubes closed at one end. Gas and air bubbles in water are necessarily flattened by the hydrostatic pressure. It is upon that principle that a gun of soft ductile iron often bulges out at the breech.

which the cylinders are fixed to, and work from, the smoke-box plates, the alternate forward and backward strains by the steam pressure on the piston have been observed to weaken, and to subject to corrosion and leakage, the substance of the plate along the edge of the angle-iron at the junction with the barrel. In further corroboration of this doctrine, Mr. Colburn states that he is not aware that any accidents from furrowing of boiler plates have taken place in the United States; and we believe that their immunity from accidents from this source is to be ascribed to the use of very thin boiler plates, quarter to five-sixteenths of an inch thick." (Pages 15 and 16.)

We will now see whence Mr. D. K. Clark got his notion "that the furrowing of plates at the rivetted joints results from the indirectness of the strain of the steam pressure." At page 6 of his work I find that he mentions, *en passant*, an able pamphlet published by Mr. A. H. Renton, C.E., in 1856, on Bertram's patent welding process (London: J. Scadding). This gentleman also furnished Mr. Clark with a number of experiments made at Woolwich by the Admiralty, in order to test the resistance of plate joints, and more especially Bertram's joint.

"The comparative strain," says Mr. Renton, "which the samples of single rivetting bore (though in some slight degree influenced by its length) was from 40 to 60 per cent. of that borne by the solid plate, the thinner plates bearing the larger proportion—that is, the strength of the three-eighth inch lapped plates was 60 per cent. of that of the solid plates, while that of the half-inch plates was only 40 per cent., whereas the proportionate section of metal between the rivets was $62\frac{1}{2}$ per cent. in both cases.

"It will be obvious from a reference to Tredgold's formula in the first vol., 'Trans. Inst. Civ. Eng.,' that the resistance of any given section, when the line of the straining force is not in the axis of the material, is in the ratio of $\frac{t}{4t - 6d}$ compared with that of the coincidence of the two as unity, in which d is the distance between the nearest side of the section and the axis or line of the force applied, and t, the thickness of the plate, from which it is evident that the resistance decreases in a much higher ratio than the area of the section increases; and hence the inadequacy of an increased thickness of plate to obtain a proportionate increase of strength—an objection to which the scarf-welded joint is not liable, as the full strength of the plate is always obtained."

of records extant on boiler explosions. This is more especially the case with regard to wear and tear caused by the direct action of steam unmasked by the effects of the fire, as the barrel and outside fire-box of a locomotive cannot be said to be under the direct action of the heat. Perhaps the vibration of the boiler through the motion on the line may intensify this action, but it is clear that vibration cannot be a primary cause. The majority of the reports are illustrated by careful drawings. Eighteen of the forty boilers gave way at the fire-box—eleven from the crown of the inside fire-box being blown down upon the tube plates; seven from the shells or sides giving way; twenty burst at the barrel; and two may be ascribed to miscellaneous causes, from an originally defective plate, and from running off the line. Leaving out all those which occurred at the fire-box, as the majority of these might be ascribed to other influences than direct pressure, all the twenty explosions of the barrel could be traced either to internal furrows or to cracks, both running parallel with one of the longitudinal joints of one of the rings forming the barrel. All the joints which thus gave way were lap-joints; and the furrows or the cracks (and the former greatly preponderate in number) occur at the edge of the inside over-lap, and therefore, just at the point where the diminution of diameter caused by the lap-joint would be most affected by the pressure of the steam.

"The plate at the channels shows distinct traces of lamination through the cross-bending, and it is probable that plate of a good material will gradually laminate, while inferior metal will crack through in less time. Nor are these furrows found with only lap-joints. Butt-joints, with a strip inside the boiler, and thus destroying the equilibrium of internal pressure, have been found to be attended with similar furrows. Channels of exactly the same character have been observed in locomotive boilers with lap joints, which have exploded in Germany.*

"Similar furrows, again, have been noticed in marine boilers, and in old boilers generally, longitudinal furrows being, of course, about twice as dangerous as those appearing transversely. The smoke-box tube plates of inside cylinder locomotive engines have been found to be similarly influenced by the racking action of the engines, showing furrows around the cylinder flanges. A parallel case is often found in Lancashire with the end-plates of double-flued Fairbairn boilers, which may have been too stiffly stayed to the barrel. Circular furrows, caused by the confined motion of the end-plates are sometimes found at the base of the angle iron rings jointing the internal flues to the end-plates. But furrowing seems with no kind of boiler to be more felt than with locomotive boilers. This is due to the high pressure, to the thicker plates causing a coarser lap, and more especially to the fact that the unstayed barrel cannot be thoroughly examined without drawing the tubes, thereby enabling the furrow to enlarge itself unnoticed.

* Organ fur die Fortschritte des Eisenbahnwesens. 1864, p. 159.

As to Mr. D. K. Clark's having first put forward the explanation that furrows are caused by an alternate buckling of the plate, such an illusion would be dispelled by a perusal of the late Mr. Frederick Braithwaite's paper, "On the Fatigue of Metals," read in 1854, before the Institution of Civil Engineers. This brief explanation, due to Mr. Braithwaite, was adopted by Mr. D. Gooch, in a letter to the Board of Trade, published four years before the issue of Mr. D. K. Clark's book. Similarly, in 1859, Mr. Adamson, of Hyde, discussed these matters of furrowing before the Institution of Mechanical Engineers of Birmingham, as an action well known by engineers to be due to alternate buckling, or, indeed, to anyone who had bent to and fro a piece of wire or of plate.

"The inside fibres of a plate bent up while cold are necessarily initially in a state of compression. When the pressure from the inside comes on, striving to form a perfect cylinder, the plate gets bent to and fro by its own elasticity on one side, and by the pressure on the other. If the iron be brittle, it may crack right through; if ductile, the outside fibres gradually lose their elasticity, and, necessarily aided by other causes, crack away. This action is progressive, and probably very rapid towards its later stage. Once a weak place formed itself, it would have to do more and more of the work. Even when pulled by the direct tension of the testing machine, a lap-joint behaves in a somewhat similar way. For instance, a ½-in. lap, solidly welded by Bertram's process, has only half the strength of the solid plate;* while the three-eighths of an inch lap-weld has actually two-thirds of the strength of the solid plate. . . .

"There is, however, another important appearance to be noted with respect to these furrows. An iron cylindrical vessel under internal pressure would, of course, rupture long before it could assume a spherical shape, from its ranges of elasticity and of ductility being so short. But it may be said to be undergoing three district stresses in as many directions. There is a stress acting on the ends, and tending to rupture the boiler in two halves in a direction parallel to the axis; there is the stress which is hoop tension in a true circle, but which acts with a cross bending strain in an ordinary boiler; and there is the stress which tends to make it assume the shape of a barrel, or to bulge it out in the centre of its length. The precise action on a material of several strains like this is a portion of the strength of materials which is still completely unknown. Its probable effects might be illustrated by the ease with which a stretched india-rubber ring is cut through with a knife, or that with which a column under compression is broken by a blow from a hammer, or by the similar ease with which a tube under tension is split by a sharp blow; in fact, the operation of caulking a defective boiler under steam seems to often give it the finishing stroke which causes an explosion. The new boiler which burst from a defective plate at the Atlas Works, Manchester, in 1858, and that which burst through a crack at a longitudinal joint last January at Peterborough, both gave way whilst being caulked. This again accounts for the fact that adjacent boilers sometimes explode one after the other, pointing, at the same time, to the danger into which a sound boiler may be thrown by an explosion. Upon the same principle it is probable that the modern guns, built up from strained rings, will be easily put *hors de combat* by shot. The probability is that a number of

* "Recent Practice on the Locomotive Engine," p. 5.

simultaneous strains in different directions diminish the elasticity of the material that would allow it to yield in any given direction. However this may be, it will be seen that it is only the pressure on the ends of the boiler acting parallel to the axis, and tending to tear the cylinder through transversely, which bears fairly on the rivetted joint, or rather on that metal between the rivets which is left after punching. Unless the cylinder be perfectly correct inside, the circumferential strain resolves itself into cross bending, shifting the dangerous section from the iron left after punching to the metal at the over-lap. With respect to the stress tending to bulge the cylinder in the centre, it is clear that if we suppose a strip cut out from the entire length of the boiler, each portion of the length of this strip could be regarded as a beam under an uniformly distributed load. As, however, with the lap joint there is a double thickness of metal transversely, that joint is the strongest and stiffest portion to resist the stresses tending to bulge out the cylinder in the middle, and also to tear it into two halves. This affords some justification for the belief of old boiler-makers before rivetted joints were tried under a direct tensional load, that the joints are the strongest parts of the boiler. And, indeed, this is what we find in practice. The thinnest portion of the longitudinal furrows is generally exactly in the middle of the plate, and this is caused by the longitudinal stress, which is acting at right angles to the transverse cross-bending stress. A strip cut from joint to joint is, in one respect, in the condition of a beam supported at both ends, uniformly loaded throughout its length, and, according to known principles, therefore giving way in the middle."

Now, if there be any virtue in words, it is clear that Mr. D. K. Clark simply assimilates the strain on a lap-joint, when made up into a boiler shell, to the tension which it undergoes by means of the straight pull of a testing machine. Amongst other little things forgotten by him is, therefore, the tendency of the imperfectly circular shell to form a correct circle. This does not, correctly speaking, cause what Mr. Clark terms "indirectness of strain," but complete cross-bending. Perhaps Mr. Clark will favour us with an explanation of the fact that butt-joints, with a covering strip inside, and with which, in the testing machine, there can be no "indirectness of strain," also lead to furrowing, while, when the plate is *outside*, no furrowing is found to take place. Mr. D. K. Clark next states, "In addition, my explanation of the destructive action of unequal expansion of the fire-box of locomotives and the shell, upon the stay bolts, in straining them laterally beyond the limits of elasticity, and thus permanently weakening them, was published at the same time [Recent Practice, pp. 16, 17], and, I think, anticipates *all* that Mr. Paget has just written on the same subject." Having been vainly striving to find an application of this assertion, perhaps Mr. D. K. Clark will kindly substantiate it by pointing to the passage in his work. I see, however, that, at page 10, the author proposes to strengthen fire-box stay bars "by straining them beyond the limits of elasticity," an operation which appears to "destroy" stay bolts, though it improves stay bars.

The only information I have borrowed from Mr. D. K. Clark's book on "Recent Practice in the Locomotive Engine" are the results he publishes of the tests conducted by the Admiralty on Bertram's welded joints. This I have acknowledged by a reference.

F. A. PAGET.

18, Adam-street, Adelphi, W.C., 15th May, 1865.

OIL FROM TEA SEED.—SIR,—In the *Journal* of the 21st April, I notice the following extract from the *Englishman*:—"It has lately been an important question among the tea planters what to do with the large quantity of tea-seed now available. It will, therefore, be an interesting fact for them to learn that a trial was recently made at Calcutta to produce oil from tea-seed. The result would seem to prove that three maunds of tea-seed will yield about one maund of oil. This oil is similar in appearance to olive oil." I cannot help feeling a little surprise that the *Englishman* and the tea planters of India should have to learn this "interesting fact" so late in the day—a fact, like many others of more recent western discovery, as old as the hills in the far East. Were some of those gentlemen to put themselves on board a steamer, and take a run round to Hong Kong, they would not only improve their health by a delightful two weeks' trip, but also have the pleasure of discovering for themselves the fact, that in that colony, as in China generally, tea oil is in common use for domestic purposes. In my own household, during my sojourn in that part of the world, I never used any other oil. Tea oil burns with a clear, bright light, and is free from unpleasant odour. This is one more illustration of the adage, that "There is nothing new under the sun." J. B. S.

MEETINGS FOR THE ENSUING WEEK.

MON. ...R. Geographical, 1. Annual Address, "On the Progress of Geography." By Sir R. Murchison, K.C.B.

TUES. ...Medical and Chirurgical, 8½.
Civil Engineers, 8. 1. Discussion upon Mr. Fletcher's Paper, "On the Maintenance of Railway Rolling Stock." 2. Sir Charles T. Bright, "The Telegraph to India, and its Extension to Australia and China."
Zoological, 8½.
Ethnological, 4. Annual Meeting.
Royal Inst., 4. Prof. Frankland, "On Organic Chemistry."

WED. ...Society of Arts, 8. Mr. T. M. Gladstone, "On Anchors and Cables; their History, Varieties, and Properties."
Geological, 8. 1. Mr. Joseph Prestwich, F.R.S., "Additional Observations on the Raised Beach of Sangatte, with Reference to the Date of the English Channel, and the Presence of Loess in the Cliff Section." 2. Messrs. Clement le Neve Foster and William Topley, "On the Superficial Deposits of the Valley of the Medway, with remarks on the Denudation of the Weald."
Archæological Assoc., 8½.
Linnæan, 8. Annual Meeting.

THURS...Antiquaries, 8.
Royal Inst., 4. Prof. Frankland, F.R.S., "On Organic Chemistry."

FRI.......Royal Inst., 8. Dr. H. Bence Jones, "On the Determination by the Spectrum Analysis of the Rate of Passage of Crystalloid Substances into and out of the Tissues of the Living Body."

SAT.......R. Botanic, 3¾.
Royal Inst., 4. Mr. Alexander Herschel, "On Meteorology."

PARLIAMENTARY PAPERS.

SESSIONAL PRINTED PAPERS.

Par. Numb. *Delivered on 29th April and 1st May, 1865.*

90. Bills—Merchant Shipping Disputes.
115. „ Union of Benefices Act Amendment.
119. „ Mortgage Debentures (amended by the Select Committee, and on re-commitment).
120. „ Land Debentures (amended by the Select Committee, and on re-commitment).
121. „ Land Debentures (Ireland) (amended by the Select Committee, and on re-commitment).
52. (III.) Trade and Navigation Accounts (31st March, 1865).
90. (IV.) Civil Service Estimates (Class IV.).
212. Public Debt—Account.
209. Illicit Distillation (Ireland)—Return.
211. Mails (India, China, and Australia)—Memorial.
217. Bradford (York) and Keightley Unions—Returns.
224. Judges' Lodgings—Return.
226. Rateable Property (Ireland)—Return.
Mr. Cobden—Despatch from M. Drouyn de Lhuys.
122. Bill—Constabulary Force (Ireland) Act Amendment.
203. Parsonage Houses—Return.
207. Fisheries—Account.
216. Wexford Harbour—Returns.

SESSION 1864.

507 (A X). Poor Rates and Pauperism—Return (A).
123. Bill—Bank Notes Issue (as amended in Committee, and on Re-commitment).
66 (VII). Railway and Canal Bills—Eighth Report from the General Committee.
186. East India (Staff Corps)—Return.
195. Population, &c.—Return.
222. Greenwich Hospital—Paper.
233. Tenure and Improvement of Land (Ireland)—Return.
237. Barracks (Ireland)—Return.
65 (VII). Committee of Selection—Eighth Report.
90. Civil Service Estimates—General Abstract.
205. Poaching Prevention Act (Cases Reported)—Return.
205 (I). Poaching Prevention Act (Expenses of Prosecutions)—Return.
227. Royal Dockyards—Papers.

239. Civil Service Estimates (1865-6)—Abstract showing Grants proposed, the sums voted "on account," and sums required to complete the several Grants.
248. Greenwich Park (South Eastern Railway—Minutes of Proceedings.
Commercial Reports from Her Majesty's Consuls in Japan.
124. Bill—Bank Notes (Ireland).
181. Militia Regiments (Establishment)—Return.
228. Public Income and Expenditure—Account.
231. Azeem Jah (Signatures to Petitions)—Report, Evidence, &c.
245. Exchequer Bonds—Account.
Commercial Reports from Her Majesty's Consuls in China.
113. Bills—Greenwich Hospital.
124. „ Bank Notes (Ireland) (corrected copy).
200. South Eastern of Bengal or Mutlah Railway Company, &c.—Returns.
213. East India (Employment of Officers)—Returns.
223. Inland Revenue (Scotland)—Statements.
225. Belfast College—Returns.
230. Courts of Probate (London and Dublin)—Accounts.
231. Azeem Jah (Signatures to Petitions)—Corrected pages.
236. Foreign Sugar—Account.
238. Emneth Parish—Correspondence.
241. Sheep (Ireland)—Return.
242. Queen's Colleges (Ireland)—Return.
244. Fortifications—Account.
246. Russian Epidemic—Letter.
249. National Portrait Gallery—Eighth Report.
252. Manchester Spring Assizes—Return.
254. Bradford (York) and Keighley Unions—Letters.
3. (301 to 303) Railway and Canal, &c., Bills—Board of Trade Reports, Parts 301 to 303.
Ordnance Survey and Topographical Depot—Report.
Public General Acts—Cap. 1 to 16.
117. Bill Salmon Fishery Act (1864) Amendment.
3 (304). Railway and Canal, &c., Bills—Board of Trade Report, Part 304.
229. Liabilities (Great Britain and Ireland)—Return.
232. Dale Dyke Reservoir—Reports of the Engineers.
240. Poor Law (Able-bodied Paupers)—Return.
253. Military Reserve Funds—Account.

Patents.

From Commissioners of Patents Journal, May 12th.

GRANTS OF PROVISIONAL PROTECTION.

Animal charcoal, reburning of—1198—T. White.
Artificial arms and hands—1185—W. E. Newton.
Bearings for mechanical purposes—109—F. G. Mulholland and T. Dugard.
Beds and bedsteads, folding—1228—W. E. Newton.
Bottles, removing corks from the interior of—1132—G. Haseltine.
Bread, &c., baking of—1108—J. Y. Betts.
Buttons, manufacture of—1199—G. A. Huddart.
Cartridge cases, charging and closing—1182—R. A. Brooman.
Chain cables, manufacture of—524—J. Shortridge.
Cranes—884—W. Irlam.
Croquet, mallets used in the game of—1181—J. F. Feltham.
Digging machinery—1124—O. C. Evans.
Driving bands, straps, &c., fasteners for—1222—J. F. Alexander and T. F. Cashin.
Drying cloths, portable hot rooms for—1135—W. Williamson.
Dyeing yarns—1193—R. Ferrie, J. Murray, and A. Wilson.
Electric telegraphs—678—H. W. Cook.
Electric telegraphs—960—A. Millar.
Embossing presses—1224—R. Fenner.
Fibrous substances, preparing and spinning—1160—W. Oxley.
File blanks, apparatus for rolling or shaping—1190—E. McNally.
File cutting machines—1172—J. Dodge.
Fire-arms—1207—E. Della-Noce.
Fire-arms, breech-loading—1177—J. Carr.
Fire-escapes—1164—T. D. Whitehead.
Flowers and leaves, arrangement of—1187—T. C. March.
Fluids, apparatus for raising—1191—J. Bernard.
Furnaces—1186—D. Simpson.
Furnaces, smoke-consuming—1152—R. A. Brooman.
Gas-ammonical engines—1074—L. de St. Ceran.
Gas engines—986—P. Hugon.
Gas regulators—1109—F. Wise.
Guns, breech-loading—1197—L. W. Broadwell.
Hydraulic pulling jacks—1176—J. Tangye.
Invalid carriages—1120—H. E. Newton.
Jacks used when roasting and baking—1106—W. Robinson.
Knife cleaning machines—1213—J. C. Davis.
Letter clips, &c., manufacture of—933—T. Corbett and R. Harrington.
Liquids, measuring the flow of—1150—T. Walker.
Liquids, steam, and gases, valves for—1226—T. Russell.
Locks and lock furniture—1194—W. H. Tucker.
Looms, pickers for—1200—G. P. Dodge.
Looms, self-acting temples for—1142—C. and G. Eastwood.
Lubricating frictional surfaces—1175—J. W. Lowther.
Machinery, regulating the power and velocity of—1230—C. W. Siemens.
Mangles—1217—W. Watts and J. J. Cooper.
Marine steam engines—1212—D. Rankin.
Masts, spars, &c., machinery for cutting—1179—S. Harvey.
Metals, compositions for preserving—1154—J. N. Brown and T. D. Clare.
Metals, furnaces for smelting and melting—1183—W. Balk.
Metals, machinery for moulding—1122—R. Canham.
Metal tubes and rods, finishing and polishing—1229—T. Allcock.
Motive power, apparatus for acquiring—1156—C. Jacquelin, jun.
Needle guns, breech-loading—1146—J. F. C. Carle.
Pencils, everpointed—1216—W. E. Wiley.
Penholders, manufacture of—1236—M. H. Beguin.
Petroleum, illuminating apparatus for burning—1237—P. A. le Comte de Fontainemoreau.
Pig iron, manufacture of—1208—H. Bessemer.
Propelling vessels—1215—M. W. Ruthven.
Reducing friable substances to powder—1178—H. W. Wood.
Resinous gum or balsam—1173—G. T. Bousfield.
Revolving shafts, apparatus for receiving the thrust of—1234—E. T. Read and J. B. Fyfe.
Rockets—1103—W. Hale.
Rocks and minerals, excavating and blasting—1192—J. Bernard.
Sewing and embroidering, machinery for—1167—G. Mumby.
Sewing machines, guide applicable to—1047—F. Bapty and E. B. Sayers.
Ships, fastening wooden planking to iron frames in—1162—W. Husband.
Sick or infirm, administering nourishment to the—1140—W. E. Gedge.
Spectacles, opera glasses, &c.—1205—J. Gutmann.
Steam engines, double cylinder—860—J. Rooke.
Tablets, tickets, &c.—1196—C. Gammon.
Textile substances, ascertaining the degree of torsion and resistance in the threads of—1235—P. A. le Comte de Fontainemoreau.
Thrashing machines, fan or exhaust for—1241—W. E. Gedge.
Utilising the heat of steam, apparatus for—854—D. E. Blacke.
Vegetable and animal substances, apparatus for disintegrating—1168—F. D. P. J. Cabasson.
Violet coloring matters, obtaining—1098—E. Smith and C. Sieberg.
Water-closets, indicators and fastenings for—1096—H. K. Taylor.
Waterproof fabrics—1219—W. E. Newton.
Water wheels—1189—A. C. Henderson.
Wood, planing and moulding—143—J. Robinson and J. Smith.
Yarns and threads, bleaching and dyeing—718—L. Gantert.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

Fog signals, apparatus for producing—1256—E. Richardson.
Printing types, machinery for setting and distributing—1271—W. Clark.
Regulating distances, engines and tools for—1245—W. F. Stanley.
Textile fabrics, drying and stretching—1233—G. T. Bousfield.

PATENTS SEALED.

2851. C. Vero.
2855. T. Restell.
2862. J. Aubin.
2871. T. Rowatt, jun.
2872. J. H. Johnson.
2874. H. Wilson.
2875. H. Wilson.
2876. A. G. Hunter.
2883. A. A. Croll.
2887. W. Wilson.
2930. G. Brunton.
2960. T. Greenhalgh.
3000. F. C. Reim.
3116. J. Ellis.
361. W. Staats.

From Commissioners of Patents Journal, May 16th.

PATENTS SEALED.

2879. W. Snell.
2882. T. A. Blakely.
2888. J. Petrie.
2899. J. Macintosh and A. H. Thurgar.
2905. S. Bourne.
2910. G. Kottgen.
2918. T. M. Brisbane.
2925. G. Prioleau.
2926. J. S. Gisborne.
2955. C. Hartley and T. Hall.
2968. W. Jackson, and J. and W. Glaholm.
2975. G. Davies.
3043. W. J. Burgess.
3061. A. V. Newton.
3111. P. A. le Comte de Fontaine-moreau.
3231. H. and E. Sutherland.
36. A. V. Newton.
52. E. Tyer.
66. L. Weber.
222. J. H. Pepper and T. W. Tobin.
564. J. Fordred.
614. J. Whitley.
640. H. W. Wimshurst.
672. W. Smith.
776. A. V. Newton.

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

1467. J. Dicker.
1406. J. T. Cooke.
1424. H. Cartwright.
1506. F. E. Sickles.
1653. W. E. Newton.
1422. J. H. Johnson.
1432. S. B. Ardrey & S. Beckett.
1440. J. H. Johnson.
1447. W. Southgood.
1450. C. T. Porter.
1455. H. Deacon.
1490. N. Ames.
1498. R. Davison and T. Johnson.
1529. H. B. Barlow.
1884. E. Hunt and H. D. Pochin.
1466. J. P. Jouvin.
1470. J. Stone.
1473. C. Attwood.
1484. A. A. Lamiable.

PATENTS ON WHICH THE STAMP DUTY OF £100 HAS BEEN PAID.

1035. W. E. Newton.
1665. H. J. Giffard.
1038. R. B. Goldsworthy.
1058. R. Halliwell.
1060. J. M. Gilbert.
1115. J. Bottomley and A. H. Martin.
1090. J. Macintosh.